Radio-frequency Interference Cancellation for Wideband Communications

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It's like noise-canceling headphones on steroids.

That's one way to think of the signal processing system that could emerge from a collaboration between New Mexico State Univ. (NMSU) and LANL researchers. Their goal is to cancel strong but unwanted radio-frequency signals so that weaker signals of interest can be detected.

Noise-canceling headphones do a fine job of canceling the drone of an airplane's engines so the user can enjoy music, but this system of the future will have a more complicated task. The interference might be a Navy vessel's radar, for instance, and the signal of interest might be covert communications between terrorists.

"It's the same principle but the technology has to be different," said Chris Brislawn, a LANL scientist and affiliated faculty member in NMSU's Department of Mathematical Sciences. "We're working at radio frequencies instead of audio frequencies and with signals propagating at the speed of light rather than the speed of sound."

Working with Brislawn are Mark Dunham of LANL's International, Space, and Response Division Office, Charles Creusere and Jaime Ramirez-Angulo of NMSU's Klipsch School of Electrical and Computer Engineering (ECE), Joseph Lakey of Mathematical Sciences, and two graduate students – Scott Izu (Mathematics) and Jose Luis Ruiz Chavira (ECE).

Noise-canceling headphones use a technology called active noise control. A microphone on the headphones picks up ambient noise, which is synthesized by electronic circuitry and fed into the headphones 180 degrees out of phase to cancel the noise. "At audio frequencies this is a tried and true method," Lakey said. "We're doing this at much higher frequencies and we're trying to do it in real time, which means we have to process and feed back our signal fast enough to make a difference."

Another complicating factor, Brislawn said, is that "we can't make any assumptions about what the signal of interest might be. We don't want to prejudice our methods in favor of any particular type of signal." For instance, Fig.1 shows a loud FM signal (synthesized in the computer) towering over a recorded urban RF background. The interference-cancellation algorithm is able to suppress this unwanted signal by over 40 dB without adversely affecting nearby potential signals of interest.

One subtlety the research must address is the fact that the amplitude of an interference signal may vary with time. Figure 2 shows a simulated FM signal whose amplitude is fluctuating on a time scale measured in microseconds. In real life this could be due to multipath interference created when a radio wave reflects off of buildings, roadways, or nearby hills, and the cancellation algorithm must accurately track the resulting variations in interference amplitude.

The researchers are working with frequencies up to 2 or 3 GHz. Cell phones, satellite broadcasts, wireless networks, garage door openers, and baby monitors all operate in that range. "One problem is that there are so many different types of signals," Izu said, "so we need to model a lot of different types of signals in order to cancel them."

Most of the work so far has been developing algorithms and computer simulations, Creusere said. "Until we know if this works in simulation, it doesn't make sense to build hardware, which would probably require designing custom integrated chips. Silicon's not fast enough, so we'll be looking at using exotic semiconductors to handle the speeds."

Ultimately such a system could have commercial as well as defense applications. "The spectrum is getting pretty crowded, with more and more devices causing interference," Lakey said. "Probably the biggest potential application would be to allow multiple devices to operate in the same part of the spectrum."

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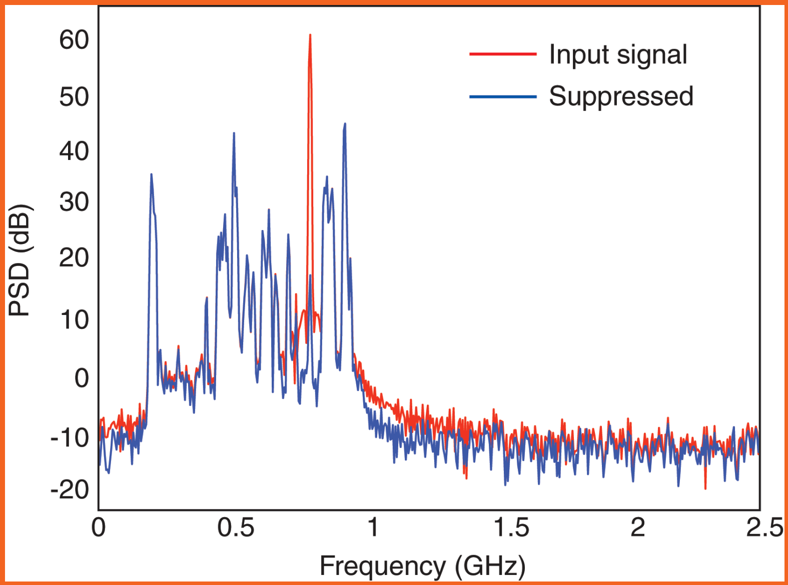

Fig. 1. Radio-frequency power spectrum showing a high-power FM interference signal before targeted cancellation (red) and after (blue).

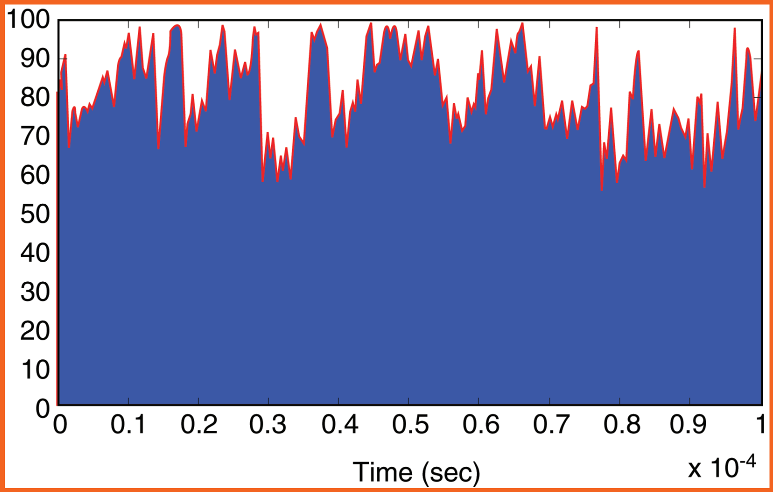

Fig. 2. Output magnitude of the interference-cancellation algorithm (red) accurately tracking an interference signal with a time-varying amplitude envelope (blue).